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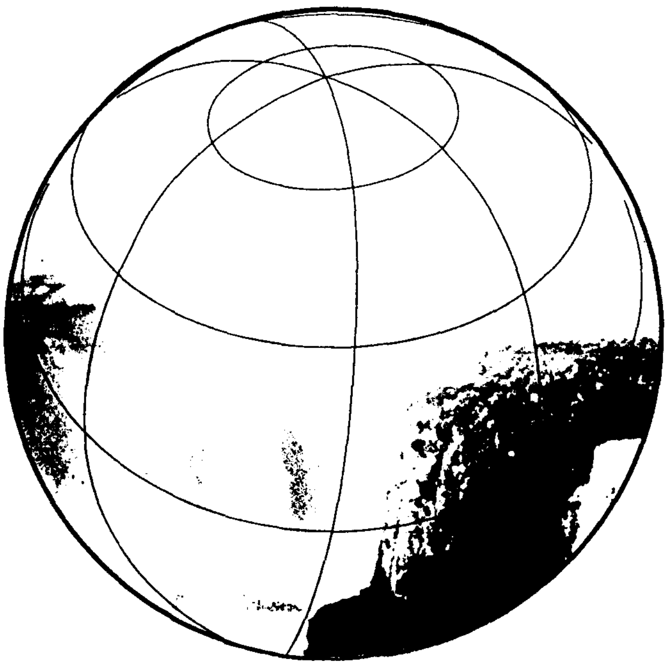

FEDERAÇÃO BRASILEIRA DE PLANTIO DIRETO NA PALHA

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CAAPAS

EFFECTS OF TILLAGE SYSTEMS, ROTATIONS, AND COVER CROP ON SOIL STRENGTH

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Abstract

Cotton (*Gossypium hirsutum* L.) production in the southern USA is generally characterized by intensive tillage operations and monoculture without use of cover crops (Reeves, 1994). The consequence of this management practice is a decrease in soil quality with consequent needs for increased inputs to offset decreased soil productivity. Reduction of soil revolving, use of cover crop and crop rotation, and increase crop intensive have been shown to reverse the process of soil degradation and improved soil quality. However, increase of soil strength (Mahboubi et al, 1993; Hill, 1990; Unger & Jones, 1998) has been reported, suggesting an increase of soil compaction which could be responsible for smaller yield obtained under no tillage (NT) compared to conventional system (CT) (Burmester et al., 1993; Touchton et al., 1989).

The use of conservation tillage, winter cover crops, and adoption of crop rotations could be a good alternative of management system. It is expected that adoption of conservation systems may promote environmental protection by increasing soil quality without decreasing profitability of cotton production.

The experiment was located at the Alabama Agriculture Experiment Station Tennessee Valley Research and Extension Center on a Decatur silt loam soil, in northern Alabama, USA. A long-term cotton rotation experiment was begun in 1979 to determine the effect of tillage systems, rotations, and cover cropping on cotton productivity. The study was initiated with CT, however, in 1988 two NT treatments, cotton with and without a wheat cover crop were added to the rotation. In 1995 all treatments except the CT controls were converted to NT.

The experiment design was a randomized complete block with four replications. Seven treatments were evaluated: 1 and 2 – Cotton monoculture under CT , with winter fallow (CTcf) and with wheat (*Triticum aestivum* L.) as winter cover crop (CTcwc); 3 and 4 - Cotton monoculture under NT, with winter fallow (NTcf) and with wheat as winter cover crop (NTcwc); 5 and 6 - Cotton-soybean [*Glycine max* (L.) Merr.] (NTcfs) and cotton-corn (*Zea mays* L.) (NTcfcr) rotation under NT, with winter fallow; 7 - Cotton-soybean/wheat (for grain) double-cropped rotation managed with NT with winter fallow in one of two years (NTcws). The experiment design was a randomized complete block with four replications. Seven treatments were evaluated: 1 - Continuous cotton, with winter fallow, crop managed with conventional tillage (conventional tillage cotton); 2 - Continuous cotton, with winter fallow, managed with no-tillage (no-tillage cotton); 3 - Continuous cotton, with wheat as winter cover crop, managed with conventional tillage (conventional tillage cotton with cover crop); 4 - Continuous cotton, with wheat as winter cover crop, managed with no-tillage (no-tillage cotton with cover crop); 5 - Cotton-soybean rotation, with winter fallow, managed with no-tillage (no-tillage cotton-soybean); 6 - Cotton-soybean/wheat double-cropped rotation managed with no-tillage with winter fallow in one of two years (no-tillage cotton-wheat/

soybean); 7 - Cotton-corn rotation, with winter fallow, crop managed under no-tillage (no-tillage cotton-corn). Conventional tillage cotton with winter fallow was disked and chisel plowed during fall, and disked and fields cultivated in spring.

Soil strength measurements were determined in May 2001, using a Rimik® CP 20 recording cone penetrometer (Agridry Rimik Pty Ltd, Toowoomba, Queensland, Australia, 4350), using a cone with a base area of 130 mm^2. Thirty locations were determined (ten in trafficked row middles, ten in nontrafficked row middles, and ten in the rows), for each plot to a depth of 60.0 cm in depth increments of 1.5 cm.

Tillage by depth interaction was observed with a clear influence of depth on the soil strength for the three sampling positions (data not shown). There was a general depth pattern for soil strength. Soil strength generally increased with depth, reaching a first peak around 10 to 20-cm depth, then decreasing until reaching minimum values around the 30-cm depth. After 30 cm soil strength began to increase again (data not shown). Corroborating with our result, Hammel (1989) also found that NT and chisel plow follow the same pattern in depth.

Both, the maximum values for the soil strength and the depth its occurrence seemed to be affected by the tillage systems (Table 1). The maximum value obtained for soil strength varied from 2000 to 2388, 1875 to 2301, and 2135 to 2614 kPa for no-traffic, row, and traffic zone, respectively. The correspondent variation for depth of the maximum soil strength was 9.8 to 21.8, 7.5 to 22.1, and 8.3 to 21.7 cm. Obviously, higher values for soil strength was noticed in the trafficked position and confirmed the effect of traffic on soil compaction (Reeves et al, 1992; Radcliffe et al, 1988).

The influence of cover cropping using was also noted by increasing the depth of occurrence for the maximum soil strength value in the row and trafficked position for NT and CT, respectively (Table 1). Maximum value for soil strength closer to the soil surface has been associated to less tillage or more traffic, in other word, more soil compaction (Larney & Kladivko, 1989; Willatt, 1986; Raper et al, 1994; Reeves et al, 1992). Therefore, in same way, the wheat cover crop attenuated the traffic effect by increasing the depth of the maximum soil strength obtained. Supporting our result, Raper et al (2000) noted that cover crop was able to improve soil condition in the Spring season, using the same soil type.

The crop intensive not only affect the depth of maximum soil strength, but also affected the maximum value for soil strength itself. The intensive cropping system (NTcws) provided deeper and smaller values for soil strength compared to cotton corn or soybean for the traffic zone. Trend for lower depth of maximum soil strength was also observed in the no-traffic and row zone for with double crop soybean-wheat under NT. It is possible that an abundance of root systems and crop residue on the soil surface could attenuate soil compaction. Disagreeing with this result, McFarland et al (1990) found no effect and increase on soil strength for NT and CT, justified by the increase on traffic requirement.

A markedly tillage effect was noticed with or without cover crop, on both conditions, the NT had shallower depth for maximum soil strength compared to CT, at the no-traffic and traffic zone. Similar result was observed at the row zone but in this time only without cover crop. Therefore, the adoption of cover crop seemed to mitigate the lack of soil revolving. The benefit of crop mulch on alleviation of soil compaction has been already demonstrated by Franzen et al (1994) under tropical condition. Like our results, shallower maximum soil strength has been observed under less disturbed systems than disturbed systems (Larney & Kladivko, 1989; Hammel, 1989; Martino & Shaykewich, 1994).

In additional, the values for maximum soil strength was also altered with lower value for CT compared to NT at the no-traffic zone and traffic zone, without and with cover crop using, respectively. A smaller value of maximum soil strength for more disturbed soil system has been demonstrated on different conditions (Radcliffe et al, 1988; Hammel, 1989; Urger & Jones, 1997). Comparison involving NT with different cotton in rotation and CTcf also showed deeper and smaller values soil strength for CT at the all position, with exception of depth for traffic zone. These results suggest that the implement pressure is concentrated on the soil surface with NT (Hammel, 1989; Martino & Shaykewich, 1994) which could be indicated of better bearing capacity of NT than CT (Culley et al, 1987; Reeves et al, 1992).

A superior values for soil strength within the plow layer under NT than more disturbed systems have been reported by many workers including: Radcliffe et al (1988), Mahboubi et al (1993), Martino & Shaykewch (1994), Hill (1990), Pierce et al (1992), and Hammel (1989).

The soil strength data clearly showed the effect of soil management. Shallower and higher values for maximum soil strength under NT than CT were a good indicator for soil compaction, the effect of cover crop and crop frequency was also demonstrated by the depth and maximum value for soil strength. On the same way, the cover crop and crop frequency benefit were also demonstrated by the depth and maximum value for soil strength.

Table 1. Effect of tillage systems, rotation, and cover crop on soil strength for a Decatur silt loam soil located in northern Alabama.

Contract	Depth for maximum soil strength (cm)			Maximum value for soil strength (MPa)		
	No traffic	Row	Traffic	No traffic	Row	Traffic
CTcf vs NTcf	20.6 x 13.5*	20.3 x 10.5*	15.8 x 9.4*	2.00 x 2.39*	1.88 x 2.05	2.14 x 2.40*
CTcw vs NTcw	21.8 x 16.1*	22.1 x 20.6	21.8 x 9.0*	2.02 x 2.19	1.93 x 2.01	2.24 x 2.55*
CTcf vs CTcw	20.6 x 21.8	20.3 x 22.1	15.8 x 21.8*	2.00 x 2.02	1.87 x 1.93	2.14 x 2.24
NTcf vs NTcw	13.5 x 16.1	10.5 x 20.6*	9.4 x 9.0	2.39 x 2.19	2.05 x 2.01	2.40 x 2.55
NTcws vs NT (cfc + cfs)	13.5 x 12.0	14.3 x 10.9	17.3 x 10.5*	2.11 x 2.35	2.04 x 2.20	2.06 x 2.58*
CTcf vs NT (cws + cfc + cfs)	20.6 x 12.5*	20.3 x 15.3*	15.8 x 12.75	2.00 x 2.27*	1.88 x 2.17*	2.14 x 2.61*

*Significant at $P \leq 0,05$.

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